APPRENTICESHIP TRAINING

Machinist Program

Alberta
LEARNING
Apprenticeship and Industry Training

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Machinist

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Course Outline

Apprenticeship and Industry Training System

Apprenticeship is post-secondary education with a difference. It helps ensure Alberta has a steady supply of highly-skilled employees, the foundation of our economy's future health and competitiveness.

Apprentices in more than 50 trades and crafts spend between one and four years learning their trade - 80% of the time on the job under the supervision of a certified journeyman or qualified tradesperson. The balance of the program is technical training in the theory, skills and technologies of their trade.

To become certified journeymen apprentices must learn theory and skills, and they must pass examinations. Requirements for certification—including the content and delivery of technical training—are developed and updated by the Alberta Apprenticeship and Industry Training Board (the Board) and a network of local and provincial industry committees.

The graduate of the Machinist apprenticeship training is a journeyman who will:

- have a thorough knowledge and understanding of the hand tools and power operated machines used for the shaping of metal into usable parts.
- be skilful in the safe use of these tools in order to produce machine parts according to specifications.
- be capable of reading and laying out projects from drawings.
- skilfully use measuring devices to reproduce machine parts according to specifications.
- know the characteristics of various metals.
- understand the effects of heat treatment on metals and be skilful in the performance of the various heat treatment processes.
- be familiar with the work in related trades such as mechanics, millwrights and welders.
- produce work economically and meet the requirements of a competitive industry.

Apprenticeship and Industry Training Committee Structure

While government supports Alberta's apprenticeship and industry training system, it is driven by industry, a term which includes both employers and employees. The Alberta Apprenticeship and Industry Training Board, with the support of Alberta Learning, oversees the system. But the system relies on a network of industry committees. These committees include local and provincial apprenticeship committees (LACs and PACs) in the designated trades and occupational committees in the designated occupations, as well as other committees such as provisional committees established before the designation of a new trade or occupation comes into effect. All these committees are composed of equal numbers of employers and employees. The network of industry committees is the foundation of Alberta's apprenticeship and industry training system.

Local Apprenticeship Committees (LAC)

Wherever there is activity in a trade, the Board can set up a LAC. The Board appoints equal numbers of employees and employers for terms of up to three years. The committee appoints a member as presiding officer. Local Apprenticeship Committees:

- monitor the apprenticeship system, and the progress of apprentices in their trade, at the local level.
- help settle certain kinds of issues between apprentices and their employers.
- recommend improvements in apprenticeship training and certification to their trade's provincial apprenticeship committee.
- make recommendations to the Board regarding the appointment of members to their trade's PAC.

Provincial Apprenticeship Committees (PAC)

The Board establishes a PAC for each trade and, based on PAC recommendations, appoints a presiding officer and equal numbers of employees and employers for terms of up to three years. Most PACs have nine members. Provincial Apprenticeship Committees:

- identify the training needs and content for their trade.
- recommend to the Board the standards for training and certification for their trade.
- monitor the activities of local apprenticeship committees in their trade.
- make recommendations to the Board about the designation of trades and occupations.
- determine whether training of various kinds is equivalent to training provided in an apprenticeship program in the trade.
- may participate in resolving any apprenticeship-related disputes between employers and employees.

Machinist PAC Members

Mr. S. Deugo	Calgary	Presiding Officer
Mr. E. Chissell	Edmonton	Employer
Mr. L. Larsson	Edmonton	Employer
Mr. P. Townsend	Edmonton	Employer
Mr. R. Sond	Calgary	Employer
Mr. G. Peterson	Edmonton	Employee
Mr. D. Stez	Calgary	Employee
Mr. R. Wermann	Edmonton	Employee

The Alberta Apprenticeship and Industry Training Board (Board)

The mandate of the Alberta Apprenticeship and Industry Training Board relates to the standards and requirements for training and certification in programs under the *Apprenticeship and Industry Training Act*. The Board provides advice to the Minister of Learning on the training and certification of people in designated trades and occupations and on the needs of the Alberta labour market for skilled and trained persons. The Board also makes orders and regulations respecting standards and requirements for apprenticeship programs and the training of apprentices and for training and certification in designated trades and occupations, and the criteria or requirements for granting and recognizing trade and other certificates.

The 13-member Board consists of a chair, eight members representing trades and four members representing other industries. The trades and other industry members are equally represented by employer and employee representatives.

Safety Education

Safe working procedures and conditions, accident prevention and the preservation of health are of primary importance in apprenticeship programs in Alberta. These responsibilities are shared and require the joint efforts of government, employers, employees and the public. Therefore, it is imperative that all parties become aware of circumstances that may lead to injury or harm. Safe learning experiences and environments can be created by controlling the variables and behaviours that may contribute to or cause an accident or injury.

It is generally recognized that a safe attitude contributes to an accident free environment. Everyone will benefit as a result of a healthy, safe attitude towards prevention of accidents.

A tradesperson is possibly exposed to more hazards than any other person in the work force and, therefore, should be familiar with and apply the Occupational Health and Safety Act and Regulations dealing with personal safety and the special safety rules applying to each task.

Legal and Administrative Aspects of Safety

Accident prevention and the provisions of safe working conditions are the responsibilities of an employer and employee.

Employer's Responsibilities

The employer is responsible for:

- providing and maintaining safety equipment, and protective devices and clothing.
- ensuring proper safe work clothing is worn.
- enforcing safe working procedures.
- providing safeguards for machinery, equipment and tools.
- observing all accident prevention regulations.
- training employees in the safe use and operation of equipment.

Employee's Responsibilities

The employee is responsible for:

- working in accordance with the safety regulations pertaining to the job environment.
- working in such a way as not to endanger themselves or fellow employees.

Workplace Health and Safety's Responsibilities:
Workplace Health and Safety (Alberta Human Resources and Employment) will conduct periodic inspections of the workplace to ensure that safety regulations for industry are being observed.

Technical Training Establishment

Alberta Learning, Apprenticeship and Industry Training offer your apprenticeship training program. Staff and facilities for delivering the program are supplied by:

- Northern Alberta Institute of Technology
- Southern Alberta Institute of Technology

Procedures For Recommending Revisions To The Course Outline

Apprenticeship and Industry Training, Industry Programs and Standards has prepared this course outline in partnership with the Machinist Provincial Apprenticeship Committee.

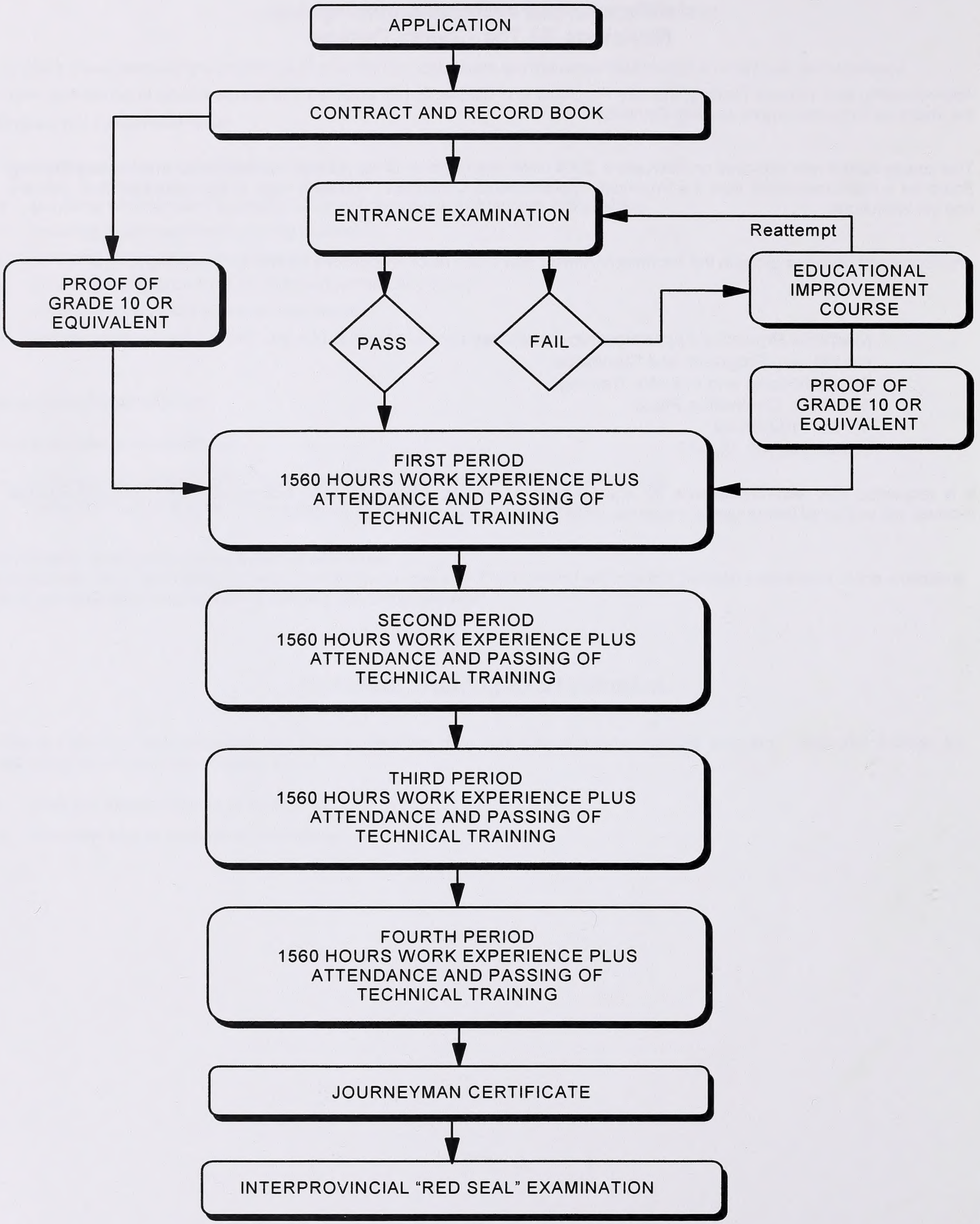
This course outline was approved on February 6, 2004 under the authority of the Alberta Apprenticeship and Industry Training Board on a recommendation from the Provincial Apprenticeship Committee. Valuable input is acknowledged from industry and the institutions.

Any concerned citizen or group in the Province of Alberta may make recommendations for change by writing to:

Machinist Provincial Apprenticeship Committee
c/o Industry Programs and Standards
Apprenticeship and Industry Training
10th floor, Commerce Place
10155 - 102 Street
Edmonton, AB T5J 4L5

It is requested that recommendations for change refer to specific areas and state references used. Recommendations received will be placed before regular meetings of the Provincial Apprenticeship Committee.

Apprenticeship Route Toward Certification



MACHINIST TRAINING PROFILE
First Period
(240 Hours)

SECTION ONE

THEORY — **72 Hours**

A WHMIS — 2 Hours	**B** Basic Measuring Tools — 2 Hours	**C** Precision Measuring Tools — 2 Hours
D Angular Measuring Tools — 2 Hours	**E** Inspection Gauges — 2 Hours	**F** Layout Tools and Procedures — 2 Hours
G Non-Cutting Hand Tools — 4 Hours	**H** Hand-Held Cutting Tools — 6 Hours	**I** Screw Thread Terminology — 5 Hours
J Screw Thread Measuring and Gauging — 3 Hours	**K** Fasteners and Locking Devices — 3 Hours	**L** Tapers — 5 Hours
M Machine Lubrication and Cutting Fluids — 2 Hours	**N** Hand Grinding Machines — 2 Hours	**O** Drilling Machines — 8 Hours
P Types of Lathes — 6 Hours	**Q** Speeds and Feeds — 4 Hours	**R** Lathe Operations — 8 Hours
S Power Saws and Cut-off Machines — 2 Hours	**T** Machine Shop Rigging — 2 Hours	

SECTION TWO

METALLURGY AND HEAT TREATMENT — **8 Hours**

A Metallurgy — 4 Hours	**B** Oxyacetylene Equipment — 4 Hours

SECTION THREE

TRADE MATHEMATICS — **24 Hours**

A Manipulation of Whole Numbers, Fractions, and Decimals. — 3 Hours	**B** Measurements and Conversions — 2 Hours	**C** Formulae and Equations — 6 Hours
D Reading Tables, Graphs and Nomographs — 2 Hours	**E** Ratio and Proportion — 3 Hours	**F** Percentage Calculations — 3 Hours
G Triangles — 5 Hours		

SECTION FOUR

BLUEPRINT READING
24 Hours

- **A** — Introduction to Blueprint Reading — 9 Hours
- **B** — Dimensioning Methods — 3 Hours
- **C** — Isometric Drawings — 4 Hours
- **D** — Sections — 4 Hours
- **E** — Applied Blueprint Reading — 4 Hours

SECTION FIVE

SHOPWORK
112 Hours

- **A** — Measurement
- **B** — Layout
- **C** — Hand Tools and Benchwork
- **D** — Threads
- **E** — Lubrication
- **F** — Hand Grinding
- **G** — Drill Presses
- **H** — Engine Lathes
- **I** — Power Saws and Cut-off Machines
- **J** — Metallurgy
- **K** — Heat Treatment
- **L** — Oxyacetylene
- **M** — Rigging

Second Period
(240 Hours)

SECTION ONE

THEORY
48 Hours

- **A** — Milling Machines — 4 Hours
- **B** — Milling Cutters — 5 Hours
- **C** — Tool and Work Holding Devices — 2 Hours
- **D** — Milling Operations — 9 Hours
- **E** — Dividing Head and Indexing — 4 Hours
- **F** — Advanced Threading — 8 Hours
- **G** — Lathe Attachments and Accessories — 4 Hours
- **H** — Advanced Cutting Tool Materials — 4 Hours
- **I** — Inserts and Tool Holders — 4 Hours
- **J** — Using Carbide Inserts — 2 Hours
- **K** — Shapers and Slotters — 2 Hours

SECTION TWO

COMPUTER NUMERICAL CONTROM MACHINES
12 Hours

A	B	C
CNC Machines: Introduction and Applications 2 Hours	CNC Turning Centers: Types, Parts and Accessories 2 Hours	CNC Turning Centers: Program and Machine Coordination 2 Hour
D	**E**	**F**
CNC Turning Centers: Cutting Conditions 2 Hours	CNC Turning Centers: program Concepts and Codes 2 Hours	CNC Turning Centers: Program Applications 2 Hours

SECTION THREE

METALLURGY
16 Hours

A	B
Base Metals and Alloys 10 Hours	Metal Specification and Testing 6 Hours

SECTION FOUR

TRADE MATHEMATICS
24 Hours

A	B	C
Measurements, Conversions, Ratio and Proportion 6 Hours	Applied Mathematics 14 Hours	Applied Geometry 4 Hours

SECTION FIVE

BLUEPRINT READING
24 Hours

A	B	C
Second Period Blueprint Reading: Part A 8 Hours	Second Period Blueprint Reading: Part B 8 Hours	Second Period Blueprint Reading: Part C 8 Hours

SECTION SIX

MACHINERY'S HANDBOOK
8 Hours

A
Machinery's Handbook 8 Hours

SECTION SEVEN

SHOPWORK
108 Hours

A	B	C
Milling Machines	Engine Lathes	Lathe Attachments
D		
CNC Machining		

Third Period
(240 Hours)

SECTION ONE

THEORY
50 Hours

A	B	C
Advanced Milling 5 Hours	Worm Threads 4 Hours	Multiple Start Threads 2 Hours
D	**E**	**F**
Introduction to Gearing 6 Hours	Gear Manufacturing Methods 8 Hours	Abrasives 3 Hours
G	**H**	**I**
Grinding Machines and Processes 6 Hours	Boring Mills 4 Hours	Jig Boring and Grinding 2 Hours

SECTION TWO

COMPUTER NUMERICAL CONTROM MACHINES
25 Hours

J	K	L
Machine Broaching 1 Hour	Jigs and Fixtures 5 Hours	Estimating 4 Ho
A	**B**	**C**
Program Codes, Format and Applications 4 Hours	Fixed Canned Cycles 1 Hour	Linear and Circular Interpolation 1 Hour
D	**E**	**F**
Multiple Repetitive Cycles 4Hours	Tool Nose Radius Compensation 3 Hours	CNC Threading I: Introduction and Calculations 3 Hours
G	**H**	**J**
CNC Threading II: Programming andTroubleshooting 5 Hours	Tool Measurements 2 Hours	Machine Control Operation 2 Hours

SECTION THREE

TRADE MATHEMATICS
24 Hours

A	B	C
Applied Mathematics 2 Hours	Introduction to Trigonometry 8 Hours	Shop Applications of Trigonometry - Imperial and Metric 12 Hours
D		
CNC Maths 2Hours		

SECTION FOUR

BLUEPRINT READING
16 Hours

A	B	C
Third Year Blueprint Reading – Part A 6 Hours	Third Year Blueprint Reading – Part B 6 Hour	Third Year Blueprint Reading Part C 4 Ho

SECTION FIVE

MACHINERY'S HANDBOOK
16 Hours

A
Machinery's Handbook 8 Hours

SECTION SIX

SHOPWORK
117 Hours

A	B	C
Grinding	Milling	Lathe Work - Threading
D	**E**	**F**
Boring Mills	Machine Broaching	Jigs and Fixtures
G		
Computer Numerical Control Machine		

Fourth Period
(240 Hours)

SECTION ONE

THEORY
68 Hours

A	B	C
Spur Gears and Milling 2 Hours	Helical Gears 4 Hours	Worm Gears 4 Hours
D	**E**	**F**
Bevel Gears 2 Hours	Cams 2 Hours	Graduating 2 Hours
G	**H**	**I**
Splines 4 Hours	Bearing and Seals 5 Hours	Belts and Pulleys 3 Hours
J	**K**	**L**
Basic Hydraulics 4 Hours	Non-traditional Manufacturing Processes 12 Hours	Introduction to Limits and Fits 6 Hours
M	**N**	**O**
Surface Finish 6 Hours	Precision Measurement 6 Hours	Gauges and Comparators 2 Hours
P	**Q**	**R**
Calibration of Measuring Tools 4 Hours	Worplace Coaching Skills 0 Hours	Purpose of Advisory Network 0 Hours

SECTION TWO

COMPUTER NUMERICAL CONTROL MACHINES
44 Hours

A	B	C
Machine Types, Parts and Functions 4 Hours	Machine and Workpiece Co-ordinate Systems 4 Hours	Program Concepts, Codes and Structure 6 Hours
D	**E**	**F**
Machining Conditions and Operations 4 Hours	Canned Cycles: Theory 4 Hours	Canned Cycles: Program Applications 4 Hours
G	**H**	**I**
Linear and Circular Interpolation 4 Hours	Cutter Radius Compensation 4 Hours	Advanced Programming Concepts and Application 6 Hours
J		
Set-Up and Operations 4 Hours		

SECTION THREE

MACHINERY'S HANDBOOK
8 Hours

A	B
Machinery's Handbook 4 Hours	Trade Math 4 Hours

SECTION FOUR

SHOPWORK
120 Hours

A	B	C
Milling	Special Machines and Processes	Computer Numerical Controlled Machines

FIRST PERIOD TECHNICAL TRAINING

MACHINIST TRADE
COURSE OUTLINE

SECTION ONE: .....THEORY .....72 HOURS

A. WHMIS..... 2 Hours

Outcome: ***Apply the requirement of WHMIS to the worksite.***

1. Describe the three key elements of WHMIS.
2. Identify WHMIS safety hazard symbols.
3. Interpret the Material Safety Data Sheet (MSDS).

B. Basic Measurement Tools..... 2 Hours

Outcome: ***Measure components using basic tools common to the trade.***

1. Identify basic measuring tools common to the trade.
2. Measure round and flat components to $^{1}/_{64}$" or 0.5 mm accuracy.

C. Precision Measuring Tools..... 2 Hours

Outcome: ***Measure workpieces using precision measuring tools common to the trade.***

1. Identify precision measuring tools used in the machine shops.
2. Perform precision measurement with both metric and imperial measuring tools.
3. Demonstrate correct care and use of measuring tools.

D. Angular Measuring Tools ..... 2 Hours

Outcome: ***Measure workpieces using angular measuring tools common to the trade.***

1. Measure angles to within limits of plus or minus 0.5° of accuracy using a bevel protractor.
2. Measure to within 5 minutes of a degree of accuracy using a universal bevel protractor.
3. Describe dial indicators and gauge blocks for measurement and set-up operations.
4. Perform angular measurement using the sine bar method.
5. Identify three types of sine plate.

E. Inspection Gauges ..... 2 Hours

Outcome: ***Check components using various types of inspection gauges.***

1. Use fixed gauges to check the accuracy of components.
2. Define the terminology associated with limits and fits.
3. Explain the effects of temperature changes, with respect to measuring components, when applying limits and fits.

F. Layout and Procedures ..... 2 Hours

Outcome: ***Perform semi-precision and precision layout procedures.***

1. Identify the tools for layout procedures.
2. Explain the procedures for basic (semi-precision) and precision layout.

G. Non-Cutting Hand Tools ..... 4 Hours

Outcome: ***Demonstrate the correct use of non-cutting hand tools common to the trade.***

1. Select the appropriate hand tool to hold, assemble or disassemble components.
2. Describe the proper technique to hold, assemble or disassemble components.
3. Describe the use of metal stamps for marking components.

H. Hand-held Cutting Tools ..... 6 Hours

Outcome: ***Demonstrate the correct use of hand-held cutting tools common to the trade.***

1. Describe hacksaws, hacksaw blades, and hole saws.
2. Describe the parts, types, classification, shape and use of files.
3. Describe the use of scrappers and chisels.
4. Describe the use of taps and dies, stud and bolt removal tools, and the proper lubricant for these applications.
5. Describe hand reamers and their applications.
6. Describe the use of hand-held cutting pliers, hand broaching tools and abrasives.

I. Screw Thread Terminology ..... 5 Hours

Outcome: ***Interpret a thread design.***

1. Define the term screw thread and list four screw thread applications.
2. Identify the parts of external and internal screw threads.
3. Identify eight screw thread forms and their applications.
4. Explain the terminology associated with thread classification and fits.

J. Screw Thread Measuring and Gauging ..... 3 Hours

Outcome: ***Inspect screw thread forms using five gauging and measuring methods.***

1. Perform thread calculations for four thread forms.
2. Describe the various methods used to accurately measure and gauge threads.

K. Fasteners And Locking Devices ..... 3 Hours

Outcome: ***Select a threaded or non-threaded mechanical fastener to meet job specifications.***

1. Identify types of threaded fasteners and their applications.
2. Identify types of non-threaded fasteners and their applications.

L. Tapers ..... 5 Hours

Outcome: ***Apply taper systems to machining operations.***

1. State four applications of tapers.
2. Identify the individual parts of a taper.
3. Describe the various methods used to measure or gauge an external or internal taper for fit and accuracy.
4. Identify eight taper systems and their applications.
5. Perform calculations for both metric and imperial tapers.

M. Machine Lubrication and Cutting Fluids ..... 2 Hours

Outcome: ***Apply lubricants to reduce friction and increase efficiency.***

1. Describe the purpose of lubrication.
2. Interpret lubrication schedules from manufacturer's specifications and apply the appropriate lubricant.
3. Identify the various methods used to apply lubricants.
4. Describe the characteristics and functions of a cutting fluid.
5. Describe the applications and potential health hazards of cutting fluids.

N. Hand Grinding Machines ..... 2 Hours

Outcome: ***Perform off-hand grinding on the bench or pedestal grinder.***

1. Identify three types of hand grinding machines and the types of wheels they use.
2. Describe the correct method to install, true and dress a grinding wheel.

O. Drilling Machines..... 8 Hours

Outcome: ***Describe the procedures to operate drilling machines.***
Identify seven types of drilling machines, their main parts and attachments.

1. Describe the various types of drill press operations.
2. Describe tool and work holding devices.
3. Identify the parts of a twist drill and the types of twist drill materials.
4. Describe special types of drills and reamers.
5. Explain metric, fractional, letter and number drill sizes and methods of measuring drill sizes.
6. Describe the different procedures for grinding a drill bit and the techniques used to correct for drilling problems.
7. Calculate the correct speeds and feeds for drill press operations.

P. Types of Lathes..... 6 Hours

Outcome: ***Describing the sizing, parts, accessories and attachments of lathe types.***

1. Identify the types, size, and related capacity of lathes found in industry.
2. Describe the five major parts of an engine lathe and their functions.
3. Explain the use of work holding devices when used on the lathe.
4. Describe lathe accessories and their applications.
5. Explain the use of tool posts and cutting tool holders.
6. Prevent potential hazards by following the safety procedures when operating lathe.

Q. Speeds and Feeds..... 4 Hours

Outcome: ***Determine the feed, speed, and depth of cut for turning operations.***

1. Describe the composition and characteristics of six types of cutting tool materials.
2. Identify the shapes, angles and clearances, when grinding a cutting tool.
3. Calculate the speeds and feeds for various cutting tool and workpiece materials.
4. Determine the depth of cut and feed rate based on five determining factors.

R. Lathe Operations..... 8 Hours

Outcome: ***Perform engine lathe set-ups and operations safely.***

1. Set-up the cutting tool to perform parallel turning and boring operations.
2. Operate a lathe to turn a shoulder.
3. Perform center drilling, drilling and reaming operations.
4. Set-up a lathe to cut tapers.

5. Perform knurling, grooving, parting-off, forming and profiling, in the lathe.
6. Use taps, dies, and a single point tool to cut a thread.
7. Describe the use of steady rests, follower rests, and mandrels on the lathe.
8. Follow safety guidelines when performing finishing operations in the lathe.

S Power Saws and Cut-off Machines ..... 2 Hours

Outcome: ***Operate power saws and cut-off machines safely.***

1. Describe the types, design features, and applications.
2. Demonstrate the correct procedures when using power saws and cut-off machines.
3. Select a saw blade or cut-off wheel.

T. Machine Shop Rigging ..... 2 Hours

Outcome: ***Comply with Occupational Health and Safety Regulations when hoisting machine components in the machine shop.***

1. Describe rigging hardware and the safety factor associated with each item.
2. Demonstrate hoisting procedures and methods of calculating sling tension and load weight.

SECTION TWO: ..... METALLURGY AND HEAT TREATMENT ..... 8 HOURS

A. Metallurgy ..... 4 Hours

Outcome: ***Select the correct type of metal for an application.***

1. Explain five physical and mechanical properties of steel and the factors that change these properties.
2. Describe steel processing and finishing methods and the shapes that may be produced by rolling.
3. Demonstrate the use of the SAE-AISI classification system to identify metals.
4. Describe heat-treating and the terminology associated with these processes.

B. Oxyacetylene Equipment ..... 4 Hours

Outcome: ***Use oxyacetylene equipment for heating, cutting and silver brazing. Use the appropriate safety precautions and devices.***

1. Describe oxygen and acetylene cylinders and the nature and production of the gases.
2. Install oxyacetylene equipment safely.
3. Describe set-up, pressure and flame adjustment, and shutdown, when using oxyacetylene equipment.
4. Perform heating, cutting and silver brazing operations.

SECTION THREE: ..... TRADE MATHEMATICS ..... 24 HOURS

A. Manipulation of Whole Numbers, Fractions and Decimals ..... 3 Hours

Outcome: ***Manipulate whole numbers, fractions and decimals.***

1. Solve problems involving addition and subtraction of whole numbers and decimals.
2. Solve problems involving multiplication and division of whole numbers and decimals.
3. Calculate the average of several numbers.
4. Factor fractions to lowest common denominator.
5. Calculate the lowest common multiple.
6. Add and subtract fractions.
7. Multiply and divide fractions.
8. Solve exponential problems involving whole numbers and fractions.
9. Convert fractions to decimals and vice versa.
10. Round off whole numbers, fractions and decimals.

B. Measurements and Conversions ..... 2 Hours

Outcome: ***Calculate measurements and conversions using metric and imperial measurement systems.***

1. List the basic metric units of length, mass, volume, time and temperature with their symbols.
2. Define the prefixes used to indicate large and small quantities.
3. List the derived metric units and their symbols.
4. Convert imperial units to metric and vice versa using tables and calculators.
5. List the conversions and equivalents for Imperial measurement.

C. Formulae and Equations ..... 6 Hours

Outcome: ***Manipulate formulae and equations.***

1. Recognize and be able to manipulate formulae according to the proper rules (postulates or axioms):
   a) addition property
   b) subtraction property
   c) multiplcation property
   d) division property
   e) exponent property
   f) index or root property
2. Group expressions according to their sequence of operations and be able to solve problems using these rules.
3. Compute various problems with the use of proper formulae in both imperial and metric:
   a) circumference of a circle
   b) area of circles
   c) perimeter of a square
   d) perimeter of a rectangle
   e) area of a square
   f) area of a rectangle

g) area of a right triangle
h) area of a triangle if the lengths of all three sides are known
i) volume of a cube
j) volume of a rectangular solid
k) volume of a cylinder

D. Reading Tables, Graphs and Nomographs ..... 2 Hours

Outcome: ***Read tables, graphs and nomographs.***

1. Read and interpret tables and graphs available to provide information to the machinist:
   a) decimal equivalent conversion
   b) squares
   c) cubes
   d) square root
   e) cube root
   f) area of circle

E. Ratio and Proportion ..... 3 Hours

Outcome: ***Define and use ratio and proportion.***

1. Define ratio.
2. Define proportion:
   a) extremes
   b) means
3. Apply ratio and proportion formulae in solving various shop problems:
   a) single pulleys
   b) gear trains
   c) compound
   d) pulleys
   e) spur gears
   f) worm gears
   g) proportion of alloy compositions

F. Percentage Calculations ..... 3 Hours

Outcome: ***Calculate and change percentages.***

1. Calculate percent for various mathematical expressions:
   a) whole numbers
   b) fractions
   c) decimals
   d) decimal fractions
   e) ratio and proportion
2. Change percentages of various mathematical expressions:
   a) whole numbers
   b) fractions
   c) decimals
   d) decimal fractions
   e) ratio and proportion

G. Triangles ..... 5 Hours

Outcome: ***Identify and use triangles.***

1. Identify common triangles:
   a) isosceles
   b) right
   c) equilateral
   d) oblique
2. Identify parts of triangles:
   a) right angle
   b) acute angle
   c) obtuse angle
   d) hypotenuse
   e) base
   f) altitude
   g) side
3. Define and apply the Pythagorean theorem.
4. Define and apply the similar triangle method to determine the angles on a right angle triangle.
5. Identify and explain the application of three special triangles:
   a) 30-60-90
   b) 45-45-90
   c) 3-4-5
6. Demonstrate the use of ratio and proportion using special triangles to solve shop problems:
   a) thread
   b) taper and bevel calculations
   c) squares
   d) hexagon
   e) hole locations

SECTION FOUR: ..... BLUEPRINT READING ..... 24 HOURS

A. Introduction to Blueprint Reading ..... 9 Hours

Outcome: ***Read and sketch basic components.***

1. Identify the six planes of an orthographic projection and the “key view”.
2. Identify first and third angle projections, and recognize the ISO symbol for each projection.
3. Describe the types of lines used on blueprints and their applications.
4. Describe basic sketching equipment.
5. Use basic rules to apply dimensions to a component drawing.
6. Sketch and dimension simple objects in orthographic projection.

B Dimensioning Methods ..... 3 Hours

Outcome: ***Dimension and interpret various common elements.***

1. Describe the different methods of applying special dimensions to a technical element on a blueprint.
2. State the methods used to express the amount of taper on a component drawing.
3. Read dimensions on blueprints in both metric and imperial systems or dual dimensioning.

C. Isometric Drawings ..... 4 Hours

Outcome: ***Sketch pictorial drawings.***

1. Calculate for missing dimensions on a drawing.
2. Describe three types of picture views.
3. Sketch isometric drawing s on isometric lined paper.

D. Sections ..... 4 Hours

Outcome: ***Recognize and name technical elements of break lines and sectional representation.***

1. Define the terms cutting plane lines, break lines and symmetry and describe their application.
2. Describe the use of sectional views and name the types of components that would not be sectioned on a drawing.
3. Draw symbolic section lines for seven types of material.

E. Applied Blueprint Reading ..... 4 Hours

Outcome: ***Sketch and interpret machine shop drawings containing advances terminology.***

1. Calculate the limits and fits for the mating parts on working drawings.
2. Apply all dimensions and tolerances to a set of working drawings.
3. Interpret blueprints including all information generally provided on blueprints, shop drawings and sketches.

SECTION FIVE: ..... SHOPWORK ..... 112 HOURS

Shopwork experience will relate items outlined in the theory section to shop operations by producing selected shop projects. This experience should compliment the theory instruction by providing opportunities for efficient, productive and safe operation and/or demonstrations thereof.

A. Measurement

Outcome: ***Use various measurement devices.***

1. Demonstrate an ability to measure and fit with the use of various measurement devices:
   - a) steel rules
   - b) calipers
   - c) squares and surface plate
   - d) micrometers
   - e) transfer-type instruments
   - f) height and depth instruments
   - g) angle measurement
   - h) inspection gauges

B. Layout

Outcome: ***Perform layout using appropriate tools.***

1. Perform layout procedures using various layout tools:
   - a) scribers
   - b) dividers and trammels
   - c) hermaphrodite calipers
   - d) squares
   - e) combination set
   - f) surface gauge
   - g) prick punches and center punches
   - h) layout accessories
   - i) layout coatings
   - j) vernier height gauge

C. Hand Tools and Benchwork

Outcome: ***Develop ability to use hand tools.***

1. Demonstrate an ability to perform operations with the use of various hand tools:
   - a) produce flat and smooth surfaces using files
   - b) hacksaws
     - i) choose different blades and cut various materials
     - ii) blade installation
   - c) metal stamps
     - i) mark workpieces
   - d) cold chisels
     - i) flat chisel for chipping
     - ii) roundnose for grooving and drawing back drills
     - iii) diamond point and cape for grooving
   - e) scrapers
     - i) use of different scrapers for various operations

f) hand broaches
   ii) produce a keyway
g) hand reamers
   i) finish a hole

D. Threads

Outcome: ***Demonstrate thread cutting and related operations.***

1. Perform various thread cutting and related operations using the proper tools:
   a) taps
      i) cut an internal thread
   b) die
      i) cut an external thread
   c) tap and screw extractors
      i) removal of a broken rap
      ii) removal of a broken screw
   d) helicoil
      i) preparation
      ii) installation

E. Lubrication

Outcome: ***Perform lubrications on various machine tools.***

1. Perform proper lubrication requirements on various machine tools using the required lubricants:
   a) drill press
   b) lathe
   c) power saw
2. Use manufacturer's lubrication charts for:
   a) type of lubrication
   b) frequency
   c) points of application

F. Hand Grinding

Outcome: ***Demonstrate the use and maintenance of offhand and bench grinders.***

1. Demonstrate an ability to use offhand and bench grinders:
   a) grinding of standard stock steel
   b) sharpening twist drills
   c) sharpening HSS single point tools
2. Demonstrate and perform maintenance operations on grinders:
   a) dressing truing
   b) work rest and spark guard adjustments
   c) replacement of grinding wheels
   d) ring test of grinding wheels

G. Drill Presses

Outcome: ***Perform various drilling operations.***

1. Perform drilling operations using various drilling machines and attachments:
   - a) sensitive drill press
   - b) standard pillar drill
   - c) radial drill press
   - d) multi-spindle drill head
2. Demonstrate an ability to safely and efficiently perform various functions on the appropriate drill press:
   - a) drilling
   - b) reaming
   - c) power tapping
   - d) spot facing
   - e) counter boring
   - f) counter sinking
   - g) boring
   - h) proper speed and feed settings

H. Engine Lathes

Outcome: ***Demonstrate various lathe operations and set-ups.***

1. Safely and efficiently perform various set ups for different operations on the engine lathe:
   - a) 4-jaw chuck set ups
   - b) 3-jaw chuck set ups
   - c) between-center set ups
   - d) mandrel set ups
   - e) American Standard tool post
   - f) square turret tool post
   - g) quick-change tool post
   - h) calculate proper feeds and speeds and make settings
2. Demonstrate an ability to perform various operations on the lathe:
   - a) facing
   - b) turning parallel
     - i) roughing
     - ii) finishing
   - c) threading
     - i) taps
     - ii) dies
   - d) cutting threads with a single point
     - i) external
   - e) knurling
   - f) center drilling
   - g) drilling
   - h) boring
     - i) parallel
     - ii) taper
   - i) forming
   - j) filing
   - k) polishing
   - l) deburring
   - m) reaming
   - n) taper turning using a compound rest or taper attachment

I. Power Saws and Cut-Off Machines

Outcome: ***Demonstrate various operations using power saws and cut-off machines.***

1. Perform stock cutting operations on power saws:
   a) power hacksaw
   b) horizontal bandsaw
2. Perform sawing operations on the contour bandsaw:
   a) friction sawing
3. Demonstrate various functions related to bandsaws:
   a) calculation and setting of proper speeds and feeds
   b) filing of bandsaw blades
   c) installation of saw blades
   d) welding of bandsaw blades
4. Perform stock cutting operations on the abrasive cut-off machine.

J. Metallurgy

Outcome: ***Demonstrate heat treatment on small hand tools using oxyacetylene equipment.***

1. Demonstrate the safe use of oxyacetylene equipment.
2. Demonstrate oxyacetylene equipment to heat treat small hand tools.

K. Heat Treatment

Outcome: ***Perform heat treatment operations.***

1. Demonstrate an ability to perform heat treatment operations:
   a) hardening
   b) tempering
   c) using various methods of temperature control

L. Oxyacetylene

Outcome: ***Perform heating, brazing and cutting operations using oxyacetylene equipment.***

1. Demonstrate an ability to perform operations using oxyacetylene equipment:
   a) for heating
      i) extension drills and/or taps
   b) for sliver brazing
      i) carbide tips
   c) for flame cutting

M. Rigging

Outcome: ***Perform basic rigging operations.***

1. Demonstrate the use of hand signals.
2. Demonstrate and perform hoisting operations as they pertain to rigging and hardware use including:
   a) types of slings
   b) sling angles
   c) wire rope attachments
   d) securing
   e) moving, inverted and swinging loads
   f) hooks
   g) eye bolts
   h) ropes, knots and blocks
   i) chain blocks
   j) chains and grab chains
   k) shackles and rings
   l) balance beams
   m) spreader bars
   n) load levellers

SECOND PERIOD TECHNICAL TRAINING

MACHINIST TRADE
COURSE OUTLINE

SECTION ONE: .....THEORY .....48 HOURS

A. Milling Machines..... 4 Hours

Outcome: ***Describe milling machine types, parts and attachments.***
Describe the classification system for milling machine types.

1. Describe the use of the parts and controls on a knee and column, milling machine.
2. Describe the safe set-up and operation of milling machine attachments.

B. Milling Cutters ..... 5 Hours

Outcome: ***Select the correct type of milling cutter and speed and feed for a machining application.***

1. Describe the types of materials used in the construction of milling cutters, and their applications and limitations.
2. Describe the arbor driven types of cutters used for operations on the horizontal milling machine.
3. Describe the types of cutters used for vertical milling machine operations.
4. Describe the care and handling of milling cutters.
5. Calculate the cutting speed, feed and depth of cut for various cutting tool and workpiece materials.

C. Tool and Work Holding Devices..... 2 Hours

Outcome: ***Select the proper tool and work holding device for a milling operation.***

1. Describe tool holding devices and their applications for the milling machine.
2. Describe work holding devices and their applications for the milling machine.

D. Milling Operations ..... 9 Hours

Outcome: ***Describe the set-up and operation of a milling machine, using safe working procedures.***

1. Explain the difference between conventional and climb milling, and list the advantages of each.
2. Explain the difference between plain milling and face milling, and list the advantages of each.
3. Describe the set-up for cutting slots, keyways and keyseats.
4. Describe the set-up for using a slitting saw.
5. Describe the set-up for drilling and boring on a milling machine.
6. Describe the set-up for straddle, gang and from milling.
7. Describe the set-up for milling T-slots and dovetails.
8. Describe the set-up for hobbing a gear on a milling machine.

9. Describe safe procedures for operating a milling machine.

E. Dividing Head and Indexing ..... 4 Hours

Outcome: ***Describe four methods of indexing using a dividing head.***

1. Describe the applications of a dividing head, and each individual part.
2. Describe four methods of indexing.
3. Describe the use of a wide-range dividing head.
4. Describe the use of a rotary table.

F. Advanced Threading ..... 8 Hours

Outcome: ***Describe the types and uses of multiple start threads, translational threads, and taper threads. Review first period threading by completing exercises.***

1. Describe the purpose of multiple start threads.
2. Describe the types and uses of translational threads.
3. Describe taper threads and their uses.

G. Lathe Attachments and Accessories ..... 4 Hours

Outcome: ***Perform lathe operations using lathe attachments and accessories.***

1. Describe the set-up and safe application of attachments used on the engine lathe.
2. Describe the set-up and safe application of accessories used on the engine lathe.

H. Advanced Cutting Tool Materials ..... 12 Hours

Outcome: ***Describe the mechanics of chip formation, the characteristics of high-speed steel, cast alloy, and carbide cutting tool materials, their methods of manufacture and their applications.***

1. Describe the mechanics of chip formation.
2. Describe cutting tool material compositions, applications, and manufacture.
3. Describe the machining operations that use carbide tooling.

I. Inserts and Tool Holders ..... 4 Hours

Outcome: ***Choose and identify carbide inserts and tool holders.***

1. Interpret cutting tool geometry and its purpose.
2. Select and insert to provide the best operating conditions and economic performance for the job.
3. Interpret the ANSI and SI systems for the identification of carbide inserts and tool holders.

J. Using Carbide Inserts ..... 2 Hours

Outcome: ***Select the correct cutting conditions for an insert, and identify and correct any problems that might arise.***

1. State the required operating conditions for carbide tools.
2. Describe carbide tool failure and the troubleshooting methods to safely correct the problem.

K. Shapers and Slotters ..... 2 Hours

Outcome: ***Describe various types of shapers, slotters, their parts, operations and applications.***

1. Identify the crank and hydraulic shapers.
2. Describe the difference between a shaper and a slotter.
3. List safety precautions regarding shapers and slotters.

SECTION TWO:..... COMPUTER NUMERICAL CONTROL MACHINES.....8 HOURS

A. CNC Machines: Introduction and Applications ..... 2 Hours

Outcome: ***Identify and explain basic CNC concepts, types of application of CNC machines, advantages, disadvantages and safety issues.***

1. Define basic terms used in CNC programming and machining.
2. Identify and describe the types of and applications for CNC machines.
3. State and discuss the advantages and disadvantages of CNC machines.
4. Identify and discuss safety practices when using CNC machines.

B. CNC Turning Centers: Types, Parts and Accessories. ..... 2 Hours

Outcome: ***Identify and explain basic CNC concepts and applications, parts and features of CNC turning centers.***

1. Types of CNC lathes and turning centers.
2. Identify and describe the parts, functions and features of CNC turning centers.
3. Identify the elements of a CNC drive system.
4. Identify and describe workholding devices and accessories used on CNC turning.

C. CNC Turning Centers: Program and Machine Coordination ..... 2 Hours

Outcome: ***Identify, determine and explain the purpose of co-ordinate and reference points used for CNC lathe programs.***

1. Determine co-ordinate points of a workpiece for both radius and diameter programming using absolute and incremental values.

2. Identify and explain the purpose of the CNC lathe axis system.
3. Identify and state a purpose for reference points used on CNC turning centers.

D. CNC Turning Centers: Cutting Conditions ..... 2 Hours

Outcome: ***Identify, select and apply speeds, feeds and depths of cut for turning operations. You will also identify the types and purposes of common turning operations.***

1. Determine and apply cutting conditions (speeds, feeds and depths of cuts) for basic lathe operations.
2. Identify and state the purpose of basic turning operations.

E. CNC Turning Centers: Program Concepts and Codes ..... 2 Hours

Outcome: ***Identify and explain basic word address programming concepts and codes.***

1. Identify and explain elements of a word address program for a CNC turning center.
2. Identify and explain the purpose and application of preparatory (G) codes.
3. Identify and explain the purpose and application of miscellaneous (M) codes.
4. Identify, explain and apply tool, feed rate, speed and related program commands.
5. Identify, explain and apply tool and workpiece co-ordinates, and related program codes.

F. CNC Turning Centers: Program Applications..... 2 Hours

Outcome: ***Prepare and verify a word address program for CNC turning operations that include facing, cylindrical turning, center drilling and drilling operations.***

1. Identify and apply canned cycles for turning operations.
2. Write a CNC lathe program including the operations of facing, center drilling, drilling and cylindrical turning.
3. Explain methods of inputting, sorting and verifying CNC programs.

SECTION THREE:.....METALLURGY.....16 HOURS

A. Base Metals and Alloys ..... 10 Hours

Outcome: ***Select the type of metal or alloy for the required operation.***

1. Describe the physical and mechanical properties of metals.
2. Describe the applications and mechanical properties of alloying elements used in steel.
3. Describe the characteristics of seven types of ferrous metals or alloys for machining operations.
4. Describe the characteristics of nine types of non-ferrous metals or alloys for machining operations.

B. Metal Specifications and Testing ..... 6 Hours

Outcome: ***Use metal specifications to select the correct metal for an application.***

1. Interpret charts and tables to select a metal for an application.
2. Describe six methods of destructive testing of metals.
3. Describe four methods of non-destructive testing of metals.

SECTION FOUR: ..... TRADE MATHEMATICS ..... 24 HOURS

The mathematics content in this course outline should maintain relevancy to technical training and be directly related to practical job applications.

A. Measurements, Conversions, Ratio and Proportion..... 6 Hours

Outcome: ***Use measurement, conversion, ratio and proportion to solve problems.***

1. Describe and identify imperial and metric systems of measurement and their applicable units:
   a) length
   b) mass
   c) time
   d) temperature
   e) volume
   f) area
2. Demonstrate an ability to compute various problems with the use of proper formulae in both imperial and metric:
   a) taper per foot
   b) metric taper ratio
   c) tail stock offset
   d) milling speeds and feeds
   e) indexing
      i) direct
      ii) simple
      iii) differential
      iv) angular
      v) wide-range dividing head
3. Be able to demonstrate an ability to convert imperial measurements to metric and vice versa using appropriate formulae:
   a) length
   b) mass
   c) time
   d) temperature
   e) volume
   f) area
4. Demonstrate an ability to compute various problems with the use of proper formulae in both imperial and metric:
   a) circumference of a circle
   b) area of circles
   c) perimeter of a square
   d) perimeter of a rectangle
   e) area of a square
   f) area of a rectangle
   g) area of a right triangle
   h) area of a triangle if the lengths of all three sides are known
   i) volume of a rectangular solid

j) volume of a cylinder

5. Demonstrate an ability to compute various problems applying ratio and proportion formulae:
   a) single pulleys
   b) gear trains
   c) compound pulleys
   d) spur gears
   e) worm gears
   f) proportion of alloy compositions
   g) taper calculations
   h) compound gear systems
   i) similar figure calculations
   j) simple machines

B. Applied Mathematics ..... 14 Hours

Outcome: ***Demonstrate the ability to apply mathematics using various calculations, tables and charts.***

1. Demonstrate an ability to perform calculations on practical applications involving triangle theory and methods:
   a) Pythagorean theorem
   b) similar triangle method
   c) ratio and proportion
2. Demonstrate an ability to perform calculations on practical applications involving ratio and proportion formulae:
   a) percentage applications
   b) taper calculations
   c) speeds of gear systems
   d) speeds of pulley systems
3. Demonstrate an ability to read and interpret tables and charts for the following:
   a) square roots
   b) squares
   c) cube roots
   d) cubes
   e) weights (masses)
   f) indexing tables
   g) heat treatment charts and graphs
   h) screw threads

C. Applied Geometry ..... 4 Hours

Outcome: ***Demonstrate the ability apply geometry in calculation and problem solving.***

1. Identify and describe common geometric forms and terminology:
   a) parallelogram
   b) frustums
   c) sector of a circle
   d) segment of a circle
   e) tangent line
   f) quadrilateral
   g) ellipse
   h) trapezoids
   i) cylinder
   j) cone
   k) pyramid
   l) prisms
   m) sphere
   n) inscribed circle

o) circumscribed circle
p) polygon

2. Be able to calculate the area of a triangle in both imperial and metric using the base altitude method and the three side method:
   a) right triangle
   b) isosceles triangle
   c) equilateral
   d) oblique

3. Be able to make various calculations on circles in both imperial and metric using proper formulae and equations:
   a) segments
   b) sectors
   c) area
   d) circumference

4. Be able to calculate the area of an ellipse and a trapezoid in both imperial and metric using proper formulae and equations:
   a) ellipse
   b) trapezoid

5. Be able to calculate volume and weight (mass) in both imperial and metric using proper formulae and equations:
   a) cylinders
   b) cones
   c) prisms
   d) spheres

6. Demonstrate an ability to calculate area and volumes in both metric and imperial using similar-figure method.

SECTION FIVE: ..... BLUEPRINT READING ..... 24 HOURS

A. Second Period Blueprint Reading: Part A ..... 8 Hours

Outcome: ***Interpret and sketch blueprints containing advanced technical information. Identify accumulation of tolerances.***

1. Apply dimensions to tapers on sketching exercises.
2. Sketch and dimension technical element such as threads, boxes and countersinks.
3. Sketch and interpret a component in orthographic projection having a auxiliary view.
4. Sketch a pictorial drawing in isometric projection showing inclined surfaces, tapers and other technical elements.

B. Second Period Blueprint Reading: Part B ..... 8 Hours

Outcome: ***Interpret various advanced symbols and abbreviations that are commonly seen on blueprints.***

1. Apply machining allowance symbols to component drawings to meet industry standards.
2. Describe the application and definitions associated with surface finish texture symbols.
3. Describe the specification associated with surface finish texture symbols.
4. Describe the purpose of a welding symbol.
5. Interpret the elements of a welding symbol.
6. Interpret elementary weld symbols for fillet welds.
7. Interpret elementary weld symbols for groove welds.

8. Identify basic weld symbols for plug, spot, and seam welds.
9. Identify basic structural steel shapes.
10. Interpret blueprints containing welding, machining and or structural steel shapes.

C. Second Period Blueprint Reading: Part C ..... 8 Hours

Outcome: ***Sketch and interpret sub-assembly and assembly drawings. Define the purpose of assembly drawings.***

1. Sketch the layout and features typical of sub-assembly drawings.
2. Sketch the layout and features typical of assembly drawings.
3. Interpret part identification methods and bills of material on assembly drawings.
4. Interpret information found on assembly drawings and sub-assembly drawings.

SECTION SIX: .....MACHINERY'S HANDBOOK .....8 HOURS

A. Machinery's Handbook ..... Hours

Outcome: ***Use the Machinery's Handbook to locate and interpret various tables, charts, graphs, text and other relevant information applicable to machine shop operations.***

5. Describe the Machinery's Handbook and explain its advantages.
6. Explain how to find information in the Machinery's Handbook.
7. Explain how to interpret tables, charts and other information found in the Machinery's Handbook.
8. Describe the contents of the Machinery's Handbook as applicable to the second year curriculum.

SECTION SEVEN: ..... SHOPWORK .....108 HOURS

Shopwork experience should relate items outlined in the theory section to shop operations by producing selected shop projects. This experience should complement the theory instruction by providing opportunities for efficient productive and safe operation and/or demonstration of:

A. Milling Machines

Outcome: ***Set-up and operate various types of milling machines and their attachments.***

1. Demonstrate an ability to perform set-ups and operations on milling machines:
   a) horizontal and vertical milling machine work
   b) plain and face milling
   c) end milling
   d) gang and straddle milling
   e) drilling and boring
   f) climb and conventional milling
   g) milling vise set-ups
   h) direct-to-table set-ups
   i) form milling operations
   j) slitting and/or slotting operations

2. Demonstrate an ability to use various types and styles of milling cutters in milling operations: Demonstrate an ability to perform set-ups and operations on milling machines:
   a) HSS and carbide insert milling cutters
   b) plain, face and end mills
   c) fly cutters
   d) angular cutters

3. Demonstrate an ability to use various tool holding devices for milling machines and their operations:
   a) arbours - various styles
   b) adaptors
   c) boring heads
   d) collets - various types

4. Perform speed and feed selections and settings for various milling operations:
   a) imperial
   b) metric

5. Perform maintenance and lubrication requirements for milling machines.

6. Demonstrate an ability to use milling machine attachments in various milling operations:
   a) vertical milling attachment
   b) universal milling attachment

B. Engine Lathes

Outcome: ***Demonstrate an ability to cut screw threads with single point tools on the engine lathe.***

1. Demonstrate an ability to cut screw threads with single point tools on the engine lathe:
   a) metric V-thread
   b) acme threads
   c) pipe thread -NPT and API
   d) pipe thread - NPT and API
   e) external and internal threads
   f) R.H. and L.H. threads
   g) measure and/or gauge screw threads

C. Lathe Attachments

Outcome: ***Demonstrate the use of lathe attachments and their various tooling.***

1. Demonstrate an ability to use attachments and accessories for engine lathes:
   a) taper attachment
   b) milling attachment
   c) grinding attachment
   d) hydraulic tracing attachment
   e) steady and follower rests
   f) face plates
   g) toolmakers buttons
   h) stops

2. Demonstrate an ability to select and use carbide and oxide tooling:
   a) indexable inserts
   b) brazed-on tools
   c) sharpen carbide tools
      i) chip breakers
      ii) honing
   d) select proper carbide grades for various work materials

D. CNC Machining

Outcome: ***Perform CNC machining as outlined in the theory section.***

1. Demonstration on a CNC lathe to reinforce related items outlined in the theory section.

THIRD PERIOD TECHNICAL TRAINING

MACHINIST TRADE
COURSE OUTLINE

SECTION ONE: .....THEORY .....56 HOURS

A. Advanced Milling..... 5 Hours

Outcome: ***Perform advanced milling calculations and operations.***

1. Review four methods of indexing.
2. Describe six applications of helical milling.
3. Calculate the lead, helix angle and gearing for a helical milling operation.
4. Set up a universal horizontal or vertical milling machine for helical milling.
5. Set up a milling machine for short-lead helical milling.

B. Worm Threads ..... 4 Hours

Outcome: ***Perform calculations and set-up procedures to produce worm threads.***
Describe the purpose of the basic elements of plain, single enveloping, and double enveloping worm threads.

1. Calculate the size of the basic elements of a worm thread.
2. Describe the methods and materials used in the manufacture of worm threads.

C. Multiple Start Threads..... 2 Hours

Outcome: ***Perform calculations and set-up procedures to produce multiple start threads.***
Describe the characteristics and applications of multiple start threads.

1. Describe the set-up procedures to cut a multiple start thread using single point cutting tools.

D. Introduction to Gearing ..... 6 Hours

Outcome: ***Describe the basic theory of gear operation and application.***

1. Describe common types of gears and their applications.
2. Identify the terminology associated with each part of a spur gear.
3. Describe the purpose of four standard gear tooth forms.
4. Calculate the speed and gear ratios for simple and compound gears.

E. Gear Manufacturing Methods ..... 8 Hours

Outcome: ***Describe the process of manufacturing precision gear systems.***
Calculate the required dimensions when cutting a spur gear and rack.

1. Describe common methods of manufacturing and finishing gears.
2. Analyze the factors when selecting materials for manufacturing gears.
3. Describe the factors that cause premature gear failure and preventative measures.
4. Describe the inspection methods used to measure the design specifications on gears.

F. Abrasives ..... 3 Hours

Outcome: ***Select the correct type of cutting tool for abrasive operations.***

1. Explain the types and uses of abrasives.
2. Analyze the various physical and material characteristics of a wheel and relate them to the standard wheel identification system.
3. Select a grinding wheel for specific applications.
4. Explain preparation and safe installation of a grinding wheel.
5. Describe precision and non-precision finishing processes and their applications.

G. Grinding Machines and Processes ..... 6 Hours

Outcome: ***Explain grinding machines and processes.***

1. Describe surface grinders and their types, parts and holding devices.
2. Explain operations of surface grinders.
3. Describe cylindrical grinders and their types, parts and holding devices.
4. Explain the operations of cylindrical grinders.
5. Describe centerless grinders and their types, parts ad work-supporting devices.
6. Explain operations of centerless grinders.
7. Describe tool and cutter grinders, their types, parts and holding devices.
8. Explain operations of tool and cutter grinders.

H. Boring Mills ..... 4 Hours

Outcome: ***Describe the types of operations performed on boring mills.***

1. Describe types, parts and controls of horizontal boring mills.
2. Describe accessories, operations, speeds and feeds of horizontal boring mills.
3. Describe types, parts and controls of vertical and planer-type boring mills.
4. Describe accessories, operations, speeds and feeds of vertical and planer-type boring mills.

I. Jig Boring and Grinding ..... 2 Hours

Outcome: ***Explain the operation of jig borers and grinders for accurate hole location.***

1. Differentiate between the purposes and construction of jig borers and jig grinders.
2. Describe tooling and tool holding devices used on jig borers.
3. Describe tooling and tool holding devices used on jig grinders.
4. Describe work holding devices and methods of location of jig borers and jig grinders.

J. Machine Broaching ..... 1 Hour

Outcome: ***Describe broaches and broaching machines.***

1. Describe the design and application of various broaches.

K. Jigs and Fixtures ..... 5 Hours

Outcome: ***Describe the design and applications of jigs and fixtures.***

1. Describe the design principles related to jigs and fixtures.
2. Describe locating and clamping devices used in jigs and fixtures.
3. Describe the applications of jigs and fixtures.

L. Estimating ..... 4 Hours

Outcome: ***Use a machine shop estimating process.***

1. Explain the terms and concepts related to estimating.
2. Determine the cost of materials for a job.
3. Determine the cost of labour for a job.
4. Perform a final cost estimate for a job.

SECTION TWO: ..... COMPUTER NUMERICAL CONTROL MACHINES ..... 24 HOURS

A. Program Codes, Format and Applications ..... 4 Hours

Outcome: ***Identify and explain basic CNC concepts, programming codes and applications.***

1. Identify and review CNC concepts and terminology from previous learning.
2. Identify, explain and apply preparatory (G) codes.
3. Identify, explain and apply miscellaneous (M) and speed (S) codes.
4. Identify, explain and apply tool (T) and feedrate (F) codes.
5. Identify, explain and apply the block-skip function.

6. Identify, and explain the components of typical program formats.
7. Identify and apply a simple CNC program for turning centers and lathes.

B. Fixed Canned Cycles ..... 1 Hour

Outcome: ***Write a CNC program using fixed canned cycles for facing, turning and boring operations. Identify and apply fixed canned cycles for square and tapered facing operations.***

1. Identify and apply fixed canned cycles for cylindrical and tapered turning operations.
2. Identify and apply fixed canned cycles for cylindrical and tapered boring operations.

C. Linear and Circular Interpolation ..... 1 Hour

Outcome: ***Identify, program and apply linear and circular tool path motions for workpieces having cylindrical diameters, square shoulders, chamfers, tapers, and concave and convex surfaces.***

1. Identify elements of and apply linear tool path motions (linear interpolation) for turning operations.
2. Identify elements of and apply circular tool path motions (circular interpolation) for turning operations.
3. Write a CNC lathe program including linear and circular tool path motions.

D. Multiple Repetitive Cycles ..... 4 Hours

Outcome: ***Use repetitive machining cycles for turning, boring, facing, radial and face grooving, and drilling operations.***

1. Identify, explain and apply turning and boring repetitive cycles.
2. Identify, explain and apply facing repetitive cycles.
3. Identify, explain and apply pattern repeating repetitive cycles for pre-shaped forgings and castings.
4. Identify, explain and apply repetitive cycles for radial grooving operations.
5. Identify, explain and apply repetitive cycles for face grooving operations.
6. Identify, explain and apply repetitive cycles for drilling operations.

E. Tool Nose Radius Compensation ..... 3 Hours

Outcome: ***Identify and explain the purpose of TNRC for turning, facing and boring operations.***

1. Identify and explain the purpose of TNRC for turning, facing and boring operations.
2. Identify and calculate the TNRC values (offsets) using trigonometric functions.
3. Identify and explain the program codes used in TNRC for turning, facing and boring operations.
4. Locate, identify and explain the machine control requirements for TNRC.
5. Apply TNRC in CNC programs for turning centers and lathes.

F. CNC Threading I: Introduction and Calculations..... 3 Hours

Outcome: ***Identify thread parts, forms and characteristics, and perform the calculations required for programming threading operations.***

1. Identify and describe common thread nomenclature, terminology and thread forms.
2. Identify and calculate basic data required for threading.
3. Identify and determine the infeed, accumulative infeed and diameter positions for threading.
4. Identify, determine and apply cutting conditions for threading.
5. Identify and discuss the advantages and disadvantages of tool infeed methods for threading.
6. Identify, determine and state applications for acceleration, deceleration and offset distances.

G. Threading II: Programming and Troubleshooting..... 5 Hours

Outcome: ***Identify and develop CNC threading programs, select tooling and discuss problems and solutions for such operations***

1. Identify, select and apply single block programming for cylindrical threading operations.
2. Identify, select and apply canned cycles for cylindrical threading operations.
3. Identify, select and apply repetitive cycles for cylindrical threading operations.
4. Identify, select, and apply threading cycles for tapered threading operations.
5. Identify, select and apply programming for multiple start threads.
6. Identify, select and apply programming for tapping operations.
7. Identify and select inserts and tooling for threading operations.
8. Identify common threading problems, causes and solutions.

H. Tool Measurements..... 2 Hours

Outcome: ***Identify, explain and apply terms, concepts and tool measuring methods used on CNC turning centers and lathes.***

1. Identify and explain terms and concepts used in tool measurement and offsets.
2. Identify and apply manual tool co-ordinates using G50 program code.
3. Identify and apply tool geometry measurements.
4. Identify and apply tool measurement using a master reference tool and workshift.
5. Identify and apply automatic tool measurements using a qualified tool setter (Q-setter) and workshift.

I. Machine Control and Operation..... 2 Hours

Outcome: ***Identify control features and use the functions for machine set-up and operation.***

1. Identify and state the purpose of the major components and features of a typical CNC operator panel.
2. Identify the family of CNC operations and the type of procedures performed within each.
3. Identify and state the purpose of the commonly used screens and files found on CNC turning centers.

4. Identify, select and apply operation procedures for common machine operations.
5. Identify and apply procedures for program input, storage, editing, verification and testing.

SECTION THREE: ..... TRADE MATHEMATICS ..... 24 HOURS

A. Applied Mathematics ..... 2 Hours

Outcome: ***Perform calculations using applied mathematics.***

1. Demonstrate an ability to read and interpret tables, charts and graphs for the following:
   a) squares
   b) square roots
   c) cubes
   d) cube roots

B. Introduction to Trigonometry ..... 8 Hours

Outcome: ***Perform calculations using trigonometry.***

1. Identify and define terms related to right triangles and basic trigonometry:
   a) right triangle parts
      i) right angle
      ii) adjacent
      iii) opposite
      iv) hypotenuse
      v) acute angle
      vi) obtuse angle
   b) trigonometric functions
      i) sine (SIN)
      ii) cosine (COS)
      iii) tangent (TAN)
   c) trigonometric ratios
   d) trigonometric equations
2. Use tables of natural trigonometric functions to find the angles for given values.
3. Be able to properly perform functions to calculate angles for given values with the use of a calculator with trigonometric functions.
4. Be able to correctly solve problems for parts of different triangles:
   a) right
   b) equilateral
   c) isosceles

C. Shop Applications of Trigonometry - Imperial and Metric ..... 12 Hours

Outcome: ***Perform calculations using shop application of trigonometry–imperial and metric.***

1. Use trigonometry to solve common machine shop problems:
   a) thread forms
      i) "V" thread
      ii) acme
      iii) worm
   b) taper and bevel calculations

c) bevel and helical gearing
d) sine bar and sine centers
e) drill point geometry
f) tool clearance angle calculations
g) hole locations on bolt circles
h) dovetail and V-block calculations
i) helix angles
j) bolt hole circles and co-ordinate distances

D. CNC Maths ..... 2 Hours

Outcome: ***Demonstrate the ability to use CNC maths.***

1. Introduction to CNC maths.

SECTION FOUR: ..... BLUEPRINT READING ..... 16 HOURS

A. Third Year Blueprint Reading – Part A ..... 6 Hours

Outcome: ***On the completion of this module you will be able to interpret and sketch blueprints using various dimensioning systems.***

1. Describe the application of special dimensioning systems.
2. Describe and identify the characteristics associate with geometric tolerance symbols.

B. Third Year Blueprint Reading – Part B ..... 6 Hours

Outcome: ***On completion of this module you will be able to sketch and interpret various information found on a casting blueprint.***

1. Sketch and apply casting criteria to various components.

C. Third Year Blueprint Reading – Part C 4Hours

Outcome: ***Describe basic jigs and fixtures.***

1. Sketch and describe common jigs and fixtures.

SECTION FIVE: .....MACHINERY'S HANDBOOK .....8 HOURS

A. Machinery's Handbook ..... 8 Hours

Outcome: ***Use the Machinery's Handbook to locate and interpret various tables, charts, graphs, text and other relevant information applicable to machine shop operations.***

1. Describe the Machinery's Handbook and explain its advantages.
2. Explain how to find information in the Machinery's Handbook.
3. Explain how to interpret tables, charts and other information found in the Machinery's Handbook.
4. Describe the contents of the Machinery's Handbook as applicable to the second year curriculum.

SECTION SIX: ..... SHOPWORK .....112 HOURS

Shopwork experience should relate items outlined in the theory section to shop operations by producing selected shop projects. This experience should complement the theory instruction by providing opportunities for efficient, productive and safe operation and/or demonstration of:

A. Grinding

Outcome: ***Demonstrate the ability to use and select grinding materials and components for various operations.***

1. Demonstrate an ability to select proper grinding wheels for common grinding operations:
   a) surface grinding
   b) cylindrical grinding
   c) tool and cutter grinding
   d) internal grinding
2. Properly perform truing and dressing operations on various types of grinding wheels.
3. Demonstrate an ability to properly mount and balance various grinding wheels.
4. Demonstrate an ability to perform various operations on common grinders:
   a) surface grinder
   b) cylindrical grinders
   c) tool and cutter grinders
   d) internal grinders

B. Milling

Outcome: ***Demonstrate an ability to perform indexing operations for milling machine set-ups.***

1. Demonstrate an ability to perform indexing operations for milling machine set-ups.
   a) direct
   b) plain (simple)
   c) differential
   d) angular
2. Demonstrate an ability in setting up a dividing head and milling machine for common operations:
   a) helical milling
   b) differential indexing

c) milling short leads
d) gear cutting

3. Demonstrate an ability to utilise the milling machine to perform common operations:
   a) helical milling
   b) spur gear and rack

4. Perform various gear tooth measurements utilising common methods available:
   a) gear tooth vernier
   b) measurement over wires
   c) backlash measurement

C. Lathe Work – Threading

Outcome: ***Perform lathe work, treading, set-up and thread cutting operations.***

1. Demonstrate an ability to set-up and perform thread cutting on the engine lathe:
   a) multi-start thread
   b) worm thread

D. Boring Mills

Outcome: ***Perform boring mills, set-ups and operation.***

1. Demonstrate an ability to set-up and perform boring operations on the horizontal boring mill:
   a) boring
      i) parallel
      ii) taper
   b) facing
   c) drilling
   d) reaming
   e) turning
      i) parallel
      ii) taper
   f) threading

E. Machine Broaching

Outcome: ***Perform machine broaching and set-ups.***

1. Demonstrate the ability to set-up and perform broaching operations on a broaching machine.

F. Jigs and Fixtures

Outcome: ***Demonstrate various applications of jigs and fixtures.***

1. Demonstrate the proper use and application of various common jigs and fixtures:
   a) threaded fasteners
   b) bushings

G. Computer Numerical Control Machining

Outcome: ***Perform CNC programming by designing and executing a simple program on a CNC lathe.***

1. Demonstrate an ability to design and execute a simple program on a computer numerical control lathe.

FOURTH PERIOD TECHNICAL TRAINING

MACHINIST TRADE
COURSE OUTLINE

SECTION ONE: .....THEROY .....68 HOURS

A. Spur Gears and Milling ..... 2 Hours

Outcome: ***Review indexing and spur gears.***
Review four methods of indexing by completing assigned exercises.

1. Review spur gear elements and calculations.

B. Helical Gears ..... 4 Hours

Outcome: ***Identify parts of helical gears, applications for helical gears, methods of manufacturing helical gears, and an understanding of the processes used for set-up.***

1. Identify the main elements of helical gears.
2. Identify applications for helical gears, as well as their advantages and disadvantages.
3. Describe the methods used to manufacture helical gears.
4. Understand the basic set-up for helical milling of helical gears.

C. Worm Gears ..... 4 Hours

Outcome: ***Describe the various methods for producing worm gears.***

1. Describe worm gear systems, uses, applications and manufacturing.
2. Describe methods of manufacturing worm gears.
3. Describe the elements and perform calculations to manufacture worm gears.

D. Bevel Gears ..... 2 Hours

Outcome: ***Describe the applications and elements of bevel gears.***

1. Describe the types and applications of bevel gears.
2. Describe the main elements of bevel gears.

E. Cams ..... 2 Hours

Outcome: ***Describe common cams and their applications.***

1. Describe the classes and types of cams and their applications.

F. Graduating ..... 2 Hours

Outcome: ***Explain linear graduating on a milling machine.***

1. Explain the process for linear graduating on a milling machine.

G. Splines ..... 4 Hours

Outcome: ***Describe the various methods for producing splines.***

1. Describe types of splines and their applications.
2. Describe methods of manufacturing splines.
3. Describe methods of manufacturing splines.

H. Bearings and Seals ..... 5 Hours

Outcome: ***Explain how to choose and install bearings and seals.***

1. Describe the types and applications of plain bearings.
2. Describe the types and applications of roller bearings.
3. Explain bearing installation procedures.
4. Describe types and applications of seals.

I. Belts and Pulleys ..... 3 Hours

Outcome: ***Explain how to choose and install belts and pulleys.***

1. Describe the types and applications of belts and pulleys.
2. Describe methods of belt and pulley sizing.
3. Explain pulley and belt installation and maintenance procedures.

J. Basic Hydraulics ..... 4 Hours

Outcome: ***Describe simple hydraulic systems as applied to machine tools.***

1. Identify the basic components of simple hydraulic systems.
2. Describe the application of simple hydraulic systems to various machine components.

K. Non-traditional Manufacturing Processes ..... 12 Hours

Outcome: ***Describe non-traditional process used in manufacturing.***

1. Describe the processes and applications of electromechanical machining to remove metal.
2. Describe the use of thermal processes for machining metal.

3. Describe the process and applications of powder metallurgy for the mass production of parts.
4. Explain the use of static and dynamic balancing to reduce vibration in rotating equipment.
5. Describe three methods of deep-hole drilling and their applications.
6. Describe new technological advancements that are relevant to manufacturing processes.

L. Introduction to Limits and Fits ..... 6 Hours

Outcome: ***Explain how to ensure interchange ability between machined parts through the application of standards of limits, fits and quality control programs.***

1. Define the terminology related to standards of limits and fits.
2. Explain the application of standards of limits and fits to machined parts.
3. Explain the application of quality control procedures to modern manufacturing.

M. Surface Finish ..... 6 Hours

Outcome: ***Explain concepts related to surface finish.***

1. Define terms related to the production and measurement of surface finishes.
2. Identify common surface finish symbols used to indicate surface finish values.
3. Choose an appropriate machining or finishing process to produce a given surface finish.

N. Precision Measurement ..... 6 Hours

Outcome: ***Explain the use of precision measuring tools and systems for direct measurement.***

1. Explain how to use a sine bar or a sine plate to measure an angle.
2. Explain how to use precision measuring systems to measure size, flatness and surface finish.
3. Explain how a co-ordinate measuring machine (CMM) is used to accurately measure machined components.

O. Gauges and Comparators ..... 2 Hours

Outcome: ***Explain the use of inspection gauges and Comparators for indirect measurement.***

1. Explain the use of inspection gauges.
2. Explain five methods of comparison measurement.

P. Calibration of Measuring Tools ..... 4 Hours

Outcome: ***Describe methods of checking and calibrating precision measuring tools.***

1. Describe a system for determining the accuracy of micrometers and dial indicators using gauge blocks.
2. Explain the ways of determining whether a gauge is within tolerances set out for gauges.

Q. Workplace Coaching Skills ..... 0 Hours

Outcome: ***Describe the following coaching skills used for training apprentices.***

1. Identify the point of the lesson.
2. Link the lesson.
3. Demonstrate a skill.
4. Provide opportunity to practice a skill.
5. Give feedback to the learner.
6. Assess the learner's progress.

R. Purpose of Advisory Network ..... 0 Hours

Outcome: ***Describe and explain the role and purpose of the advisory network and Provincial Apprenticeship Committee for the Machinist trade.***

1. Identify and describe the various roles.
2. Explain the function of the advisory network.
3. Link the lesson.

SECTION TWO:..... COMPUTER NUMERICAL CONTROL MACHINES .....44 HOURS

A. Machine Types, Parts and Functions ..... 4 Hours

Outcome: ***Identify and explain the purpose of CNC machining centers, milling machines, their parts and functions.***

1. Identify the types of CNC machining centers and milling machines with appropriate application.
2. Identify and describe the parts, functions and features of CNC machining center.
3. Identify the elements of a CNC drive system and probes.
4. Identify and describe workholding devices and accessories used on CNC machining centers.
5. Identify and discuss safety practices when using CNC machines.

B. Machine and Workpiece Co-ordinate Systems..... 4 Hours

Outcome: ***Identify, determine and explain the purpose of co-ordinate systems, machine axes, workpiece co-ordinates and reference points used for CNC machining centers and milling machines.***

1. Identify, determine and apply co-ordinate systems and dimensions for programming.
2. Identify and explain the purpose of the machine axis system.
3. Identify and state a purpose for reference points and work co-ordinate system.
4. Identify and determine co-ordinate points for simple workpieces.

C. Program Concepts, Codes and Structure ..... 6 Hours

Outcome: ***Identify and explain basic CNC concepts, programming codes and applications.***

1. Identify and review CNC program concepts and terminology.
2. Identify, explain and apply preparatory (G) codes.
3. Identify, explain and apply miscellaneous (M) and speed (S) codes.
4. Identify, explain and apply tool (T) and feedrate (f) codes.
5. Identify, explain and apply block-skip program functions.
6. Identify, explain and apply workpiece shift and tool length offset program codes.
7. Identify components of a CNC program for machining centers and milling machines.

D. Machining Conditions and Operations Hours ..... 4 Hours

Outcome: ***Identify, select and apply speeds, feed rates and depth of cuts for common machining operations performed on machining centers and milling machines.***

1. Determine, select and apply cutting speeds for machining operations performed on machining centers.
2. Select, determine and apply feedrates for machining operations performed on machining centers.
3. Select, determine and apply depth of cut for milling operations.
4. Identify and state the purpose of common operations performed on machining centers.

E. Canned Cycles: Theory ..... 4 Hours

Outcome: ***Identify and explain the canned cycles used for drilling, boring and tapping operations performed on NCN machining centers and milling machines.***

1. Identify and explain the program variables used in canned cycles.
2. Identify, explain and apply drilling canned cycles.
3. Identify, explain and apply the tapping canned cycle.
4. Identify, explain and apply boring canned cycles.

F. Canned Cycles: Program Applications ..... 4 Hours

Outcome: ***Identify and prepare canned cycle programs for drilling type operations for CNC machining centers and milling machines.***

1. Identify and calculate co-ordinate points for typical hole patterns.
2. Identify and calculate depth of holes for drilling operations.
3. Identify and apply canned cycles for drilling type operations including tapping and boring.
4. Identify and apply canned cycles with repeat (L) function for linear and grid hole patterns.
5. Identify and apply canned cycles using polar co-ordinates.

G. Linear and Circular Interpolation ..... 4 Hours

Outcome: ***At the end of this module you will be able to identify and program linear and circular interpolation for machining purposes.***

1. Identify elements of an apply linear toolpath motions (linear interpolation) for milling operations.
2. Identify elements of circular interpolation for milling operations.
3. Identify, explain, calculate and apply arc modifiers for circular interpolation.
4. Write a CNC program including linear and circular tool path motions for machining centers and milling machines.

H. Cutter Radius Compensation ..... 4 Hours

Outcome: ***Identify, explain the purpose of, and apply cutter radius compensation (CRC) for machining workpiece profiles on CNC machining centers and milling machines.***

1. Identify and calculate the co-ordinates for cutter center path programming.
2. Identify and explain the program codes, machine setting and guidelines for cutter radius compensation (CRC).
3. Identify and state the advantages of CRC.
4. Identify and apply CRC for profile milling operations.

I. Advanced Programming Concepts and Application ..... 6 Hours

Outcome: ***Identify, select and apply special and advanced programming techniques.***

1. Identify, select and apply subprograms for appropriate machining applications.
2. Identify and state an application for macro programs.
3. Identify, select and apply mirror image for appropriate machining applications.
4. Identify, select and apply co-ordinate rotation for appropriate machining applications.
5. Identify, select and apply helical milling for thread milling operations.
6. Identify, select and apply part zero shift programming techniques.

J. Set-up and Operations ..... 4 Hours

SECTION THREE: .....MACHINERY'S HANDBOOK .....8 HOURS

A. Machinery's Handbook.....4 Hours

Outcome: ***Demonstrate ability in the use of the machinery handbook.***

1. Locate and interpret various table, charts, graphs and other pertinent information applicable to common machine shop requirements:
   - a) tables of bearings
     - i) material for plain bearings
     - ii) babbitt composition
     - iii) types and characteristics of
     - iv) antifriction bearings
     - v) fillet radius
     - vi) limits and tolerances of antifriction bearings
   - b) tables of pipes and pipe fittings
     - i) dimensions and schedules
     - ii) definitions of pipe fittings
     - iii) sizes of tubing
     - iv) seamless
     - v) welded
   - c) tables of worm gearing
     - i) formulae
     - ii) tooth proportions
   - d) tables of gear material
     - i) case hardening steels
     - ii) thorough hardening steels
     - iii) bronzes
   - e) tables for broaching
     - i) design data
     - ii) broaching pressures
   - f) tables for belt, pulleys and sprockets
     - i) dimensions and tolerances
   - g) tables for splines and clutches
     - i) symbols
     - ii) dimensions and tolerances
   - h) tables of helical gearing
     - i) arrangements
     - ii) cutter selection
     - iii) nomenclature
     - iv) change gears for milling helical gears
   - i) tables and charts for cam milling
     - i) change gears
     - ii) angles
   - j) gear data tables - Imperial and SI
     - i) application and quality numbers
     - ii) formulae for milled bevel gears
     - iii) over wire measurement spur gears
   - k) metrology tables
     - i) sine bar constants
     - ii) preferred tolerance tables
     - iii) tables of gauge dimensions
     - iv) surface finish symbols
     - v) surface finish vs roughness produced

B. Trade Math ..... 4 Hours

Outcome: ***Solve problems by reviewing trade math.***

1. Trade math review.

SECTION FOUR: ..... SHOPWORK ..... 128 HOURS

Shopwork experience should relate items outlined in the theory section to shop operations by producing selected shop projects. This experience should complement the theory instruction by providing opportunities for efficient, productive and safe operation and/or demonstration of:

A. Milling

Outcome: ***Perform various milling operations using indexing methods.***

1. Demonstrate an ability to set-up and perform milling operations using various indexing methods:
   a) cut helical gears
   b) cut worm gears
   c) mill various types of cams (demonstration only)
   d) perform graduating work
      i) linear
      ii) circular

B. Special Machines and Processes

Outcome: ***Perform special machines and process operation.***

1. Either a demonstration or perform operations using special machines and/or processes:
   a) electro discharge machining (E.D.M.)

C. Computer Numerical Controlled (CNC) Machines

Outcome: ***Perform CNC machine operation by designing and executing a simple program on a CNC center and turning center.***

1. Demonstrate an ability to design, enter and execute a simple program on a computer numerically controlled machining center and turning centers.

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